THE WEATHER AND CIRCULATION OF JUNE 1959

A Month With an Unusual Blocking Wave

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1. INTRODUCTION

Extensive blocking during the latter half of June 1959 culminated in the second lowest 5-day mean zonal index of record for June. The major blocking activity of the month had little effect in western North America, but led to substantially reduced temperature anomalies in the eastern United States where temperatures had been much above normal in May [1]. Conversely, the cold temperatures and strong mean trough over the Western States in May were replaced by predominantly much above normal temperatures and mean ridge conditions in June. Reversals of this type have been more frequent from April to May [2], though a strong May–June reversal occurred in 1955 [3].

2. GENERAL CIRCULATION

Features of the mean 700-mb. circulation (fig. 1) characteristic of blocking were the out-of-phase, "shattered" nature of mean troughs and their irregular spacing around the hemisphere. The one continuous full-latitude trough over eastern Canada and the western Atlantic was strongly distorted by the supernormal half wavelength upstream associated with confluence over southern Canada. Over the oceans at middle latitudes the mean troughs were spaced rather closely, with the blocking character of the ridges between them best revealed in the height anomaly field.

Magnitudes of the mean monthly anomaly centers were remarkably large, in view of the tremendous height changes that occurred within the month (fig. 2C). Some of the changes occurred near rather strong monthly mean centers of anomaly at high latitudes. Intensity of the strongest height anomaly center over northern Siberia varied little, but centers over the Aleutians and the Canadian Arctic, prominent in figure 1, did not appear in the mean of the first half-month (fig. 2A). While these centers were not associated with separate Highs in the monthly mean height field (fig. 1), they were related to the split Aleutian Low and the westward displacement (from normal) of the mean Low over Canada. The Arctic Low was stronger than normal, displaced toward Spitsbergen, and remained relatively unchanged through the month.

The greatest change from May (fig. 3) took place over northern Siberia, where a strong ridge displaced a deep mean trough (see fig. 1 of [1]). Downstream the Asiatic coastal trough deepened, forcing eastward the Pacific trough and a lobe of the Aleutian Low. This accounted for extensive falls in the eastern Pacific, where a strong mean ridge had dominated the May pattern. Changes downstream over the United States were smaller but sufficient to reverse almost completely the field of 700-mb. height anomaly. During this reversal general rises occurred over the Western States early in June, but the falls over the Eastern States were mainly reactions to blocking after midmonth. Negative anomalies over the Gulf States were associated with remnants of tropical storms Arlene and Beulah and two weaker tropical depressions.

Other information about the circulation can be gleaned from the mean monthly wind field at 700 mb. (fig. 4). The mean jet maximum was well defined and stronger than normal over the eastern Pacific and the eastern Atlantic. The mean jet followed the normal path rather closely over the oceans, but was located north of normal over North America. This is further indication that blocking tended to bypass the North American Continent.

The zonal index (fig. 5) underwent a complete oscillation, continuing the series of index cycles dating back to April 1959 [4]. In June the excess of zonal westerlies over normal during the first half of the month was nearly balanced by a deficit during the second half, so that the average for the month was about normal. Similar compensation occurred at most latitudes of the western sector of the Northern Hemisphere, and departures from the normal 700-mb. windspeed profile (not shown) were small.

3. BLOCKING

While blocking persisted throughout the month over Asia, its effects were negligible in the western sector of the hemisphere until after midmonth. In the first half-month (fig. 2A) the strongest anomaly centers in the western sector of the hemisphere were negative and located at middle or high latitudes. With the advent of blocking, the picture changed radically during the second 15-day period, and the negative centers were all but obliterated in the northern Pacific. A huge area of positive anomaly centered near the Aleutians became dominant there (fig. 2B), and extensions of this positive area through other strong centers in the Beaufort Sea and Baffin Bay completed an anticyclonic pattern of remarkable proportions at high latitudes in the western part of the hemisphere.

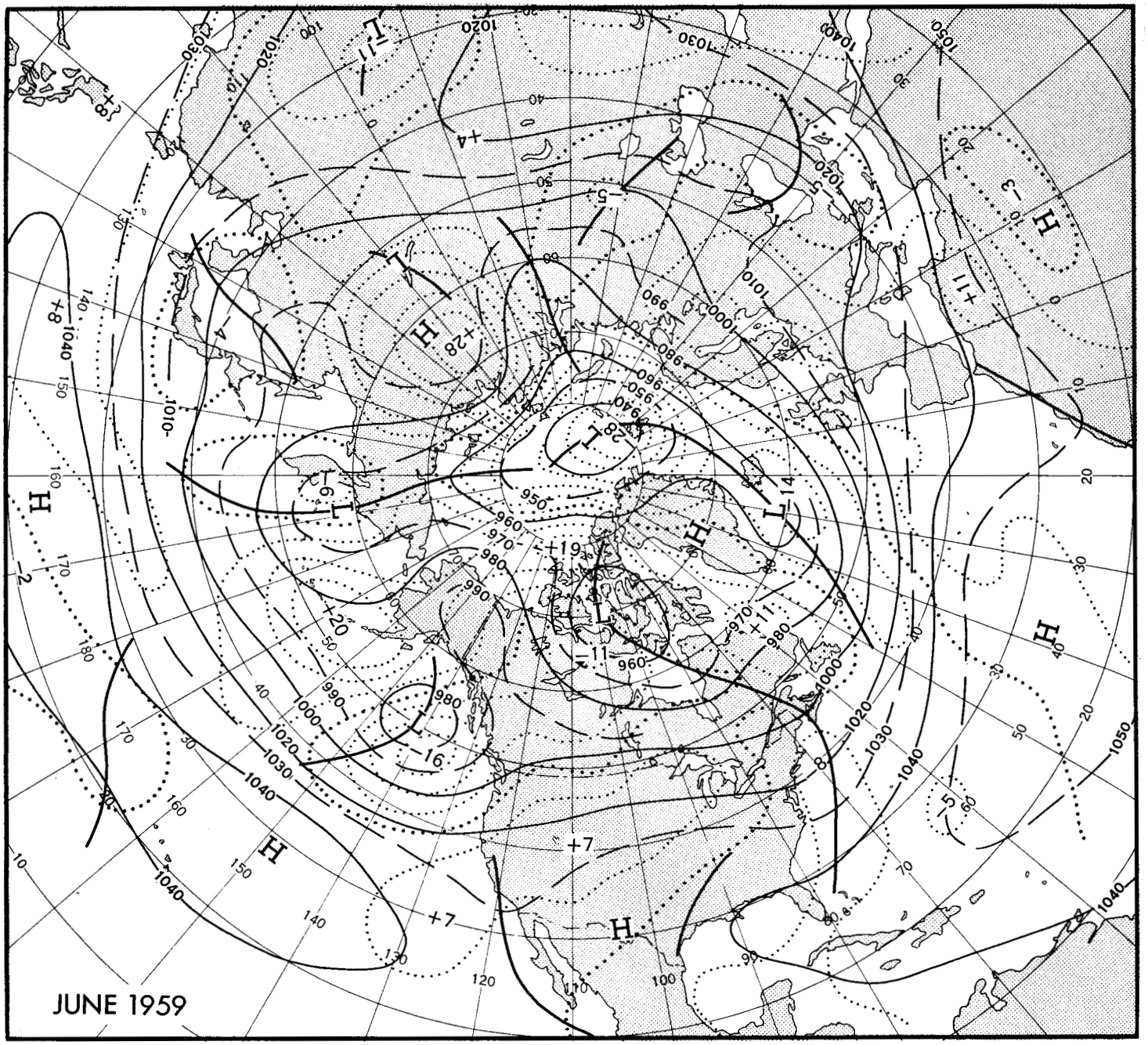

FIGURE 1.—Mean 700-mb. contours (solid) and height departures from normal (dotted), both in tens of feet, for June 1959. Blocking activity was marked in the area of positive anomaly around the northern boundary of North America from Newfoundland to southwestern Alaska.

The depressed negative centers over the Atlantic Ocean were arrayed in the "omega" pattern often observed with blocking.

Figure 6 displays a series of 5-day mean maps for periods chosen to represent the circulation by weeks. The incipient stage of a blocking wave appeared the first week (June 2–6, fig. 6A) over northwestern Russia. During this period the zonal index was high (fig. 5) in the western sector of the hemisphere, and amplitudes of waves in the strong westerly flow were small. During the same period a High just northwest of Greenland was associated with a positive anomaly of about 100 feet.

During the subsequent week, blocking spread to the Atlantic ridge, and the positive anomaly near Greenland moved southward to Hudson Bay and became more intense. The ridge in the northern Pacific pushed strongly northward, so that by June 9–13 (fig. 6B) the zonal index had been reduced to just about normal.

Thereafter the Atlantic ridge built sharply, spreading westward, to the Maritime Provinces. As positive anomalies bridged westward, the anomaly center in Hudson Bay grew in size and intensity and shifted to the Beaufort Sea. This center had joined across Alaska to the northern Pacific High by June 16–20 (fig. 6C). At this

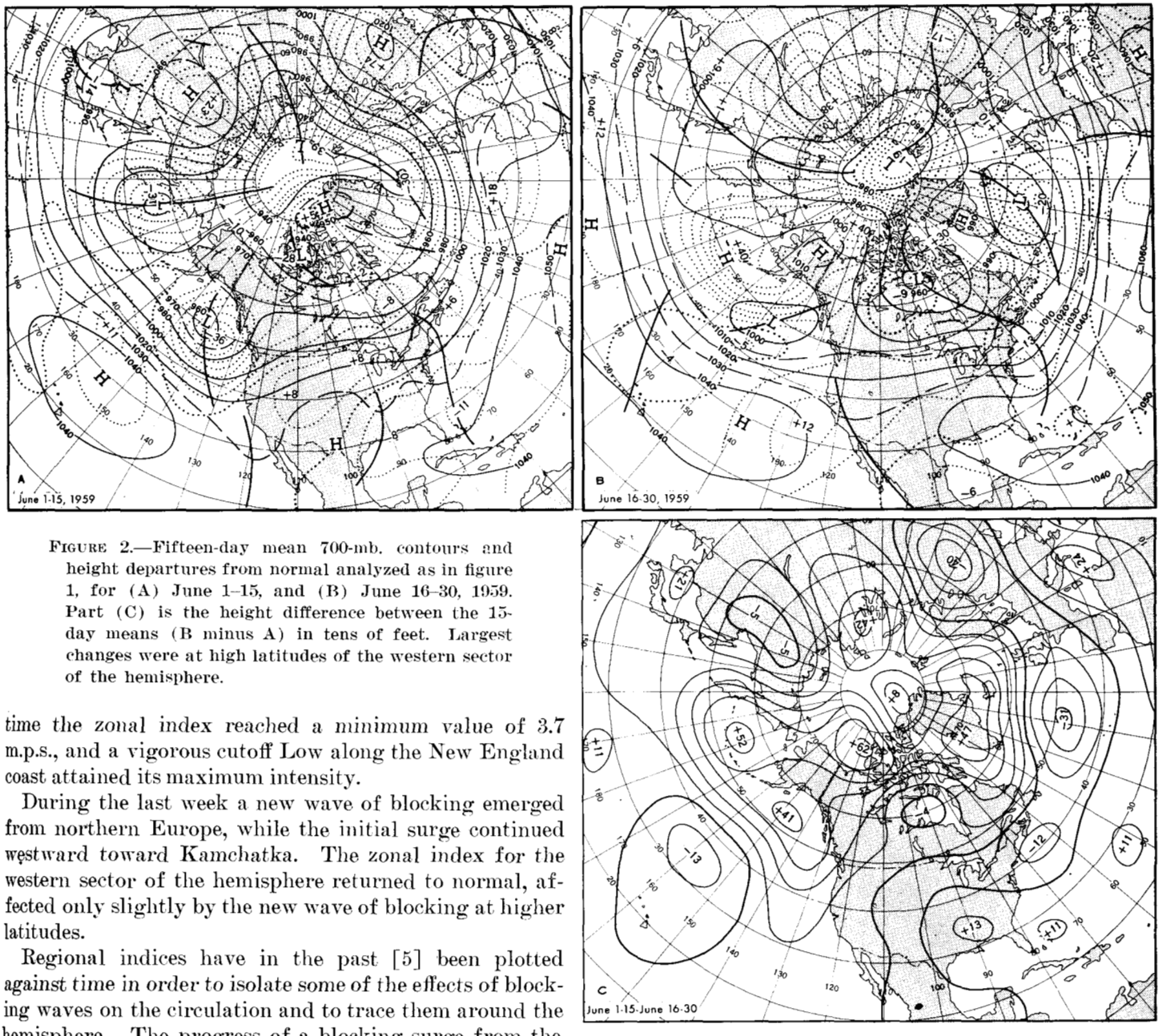

FIGURE 2.—Fifteen-day mean 700-mb. contours and height departures from normal analyzed as in figure 1, for (A) June 1–15, and (B) June 16–30, 1959. Part (C) is the height difference between the 15-day means (B minus A) in tens of feet. Largest changes were at high latitudes of the western sector of the hemisphere.

time the zonal index reached a minimum value of 3.7 m.p.s., and a vigorous cutoff Low along the New England coast attained its maximum intensity.

During the last week a new wave of blocking emerged from northern Europe, while the initial surge continued westward toward Kamchatka. The zonal index for the western sector of the hemisphere returned to normal, affected only slightly by the new wave of blocking at higher latitudes.

Regional indices have in the past [5] been plotted against time in order to isolate some of the effects of blocking waves on the circulation and to trace them around the hemisphere. The progress of a blocking surge from the eastern Atlantic to the northern Pacific is shown in figure 8. The wave moved rapidly upstream, affecting adjacent 80° zones at subsequent intervals of 3 or 4 days. It is interesting to note the extent to which the disturbance affected index values of different zones. For instance, the reaction was much greater over the oceans than over continental North America or Asia. This behavior is difficult to explain but may have been related to the eccentric location of the semipermanent Arctic Low and the strong High over Siberia.

4. TEMPERATURES

It has been noted that the monthly temperature anomaly pattern over the United States (fig. 9) strongly reflected the circulation reversal from May to June. Only 40 percent persistence (0+1 classes) was observed, much less than the 70 percent expected [2]. A reversal in 1955 [3] resulted in even less persistence, 35 percent, from May to June.

The anomaly pattern for May 1959 favored baroclinic development, with vigorous storms advecting cool air behind them along the frontal boundary separating cool air in the North and West from warm air in the East and South. Just the opposite is indicated in the pattern for June, when the boundary was also oriented southwest-northeast but separated warm air in the Northwest, from cool air in the Southeast. This and the precipitation pattern suggest that limited insolation due to cloudiness was more responsible for cool anomalies in June than advected cool air.

Abnormal warmth in the Southwest was attended by high percentages of possible sunshine, and new records

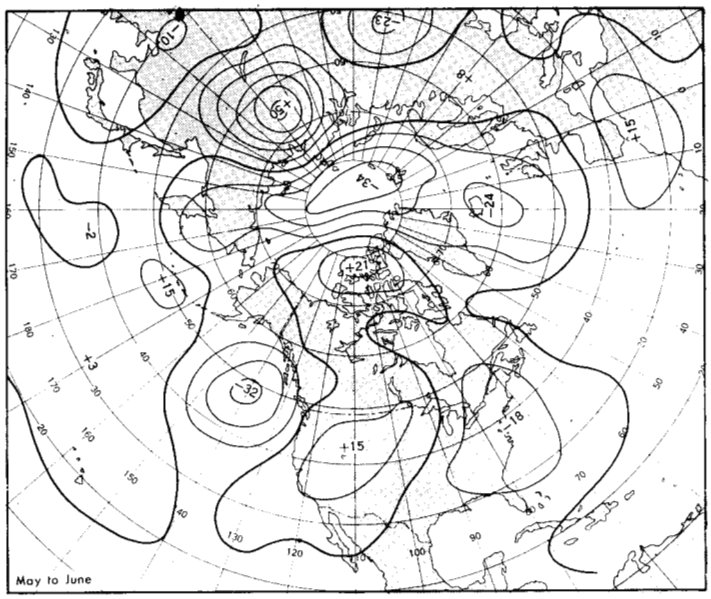

FIGURE 3.—Difference between monthly mean 700-mb. height anomalies for May and June 1959 (June minus May) in tens of feet. Changes over the United States accompanied a reversal of the temperature anomaly pattern from May to June.

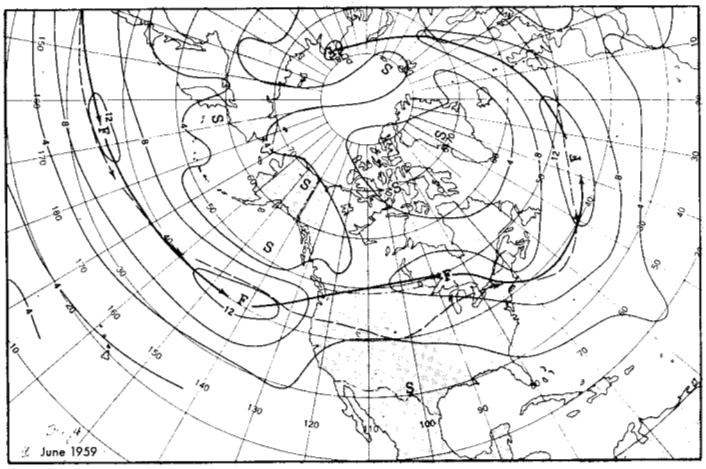

FIGURE 4.—Mean 700-mb. isotachs in meters per second for June 1959. Solid arrows indicate principal axes of mean winds and dashed arrows their normal June positions. Over the Pacific and Atlantic the axes followed closely the normal path, but northward displacement was evident over North America.

were established for both. Sacramento, Calif., reported 100 percent of possible sunshine. Ely, Nev., had new records for possible sunshine and highest average temperature. Las Vegas, Nev., Los Angeles Airport, Calif., and Yuma, Ariz., all had record high temperatures for June.

Temperature anomalies [6] for the weeks corresponding to the 5-day periods in figure 6 are shown in figure 7. The pattern for the first week was typical of that associated with a high index circulation. Warmer than normal temperatures prevailed over the West and North, and cooler than normal over the Southeast. There were relatively small changes during the second week, as some cool

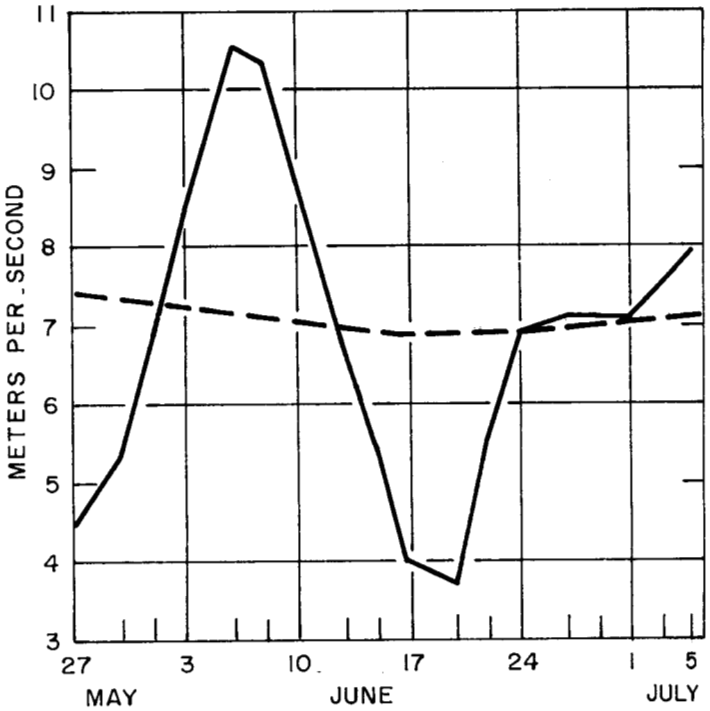

FIGURE 5.—Time variation of the 5-day mean values of the zonal westerlies in meters per second for June 1959, plotted on the last day of the period. The zonal index is computed from 35° to 55° N. for the Western Hemisphere. The minimum on the curve represents the second lowest 5-day mean index of record for June.

air filtered into the Pacific Northwest, and warming occurred from the Southern Plains to Virginia. Patterns for both weeks resembled the monthly mean temperature departure from normal (fig. 9).

Rapid cooling over the eastern third of the Nation, except for a strip along the southeastern corner, followed the onset of blocking in eastern North America the third week. Pressures rose strongly over the Maritime Provinces, cutting off a vigorous Low along the New England coast. Daily record low temperatures were reported this week from the Great Lakes to South Carolina. Frost damage occurred in Indiana, and snow was reported in the mountains of New Hampshire.

During the final week cool air again pushed into the Pacific Northwest and extended eastward to Lake Superior. Blocking relaxed over eastern North America, followed by rapid warming over the Eastern States. The month closed with a heat wave of record intensity along the Atlantic seaboard. New daily high temperature records were established at numerous stations from Columbia, S.C., to Nantucket, Mass., from the 28th through the 30th.

5. PRECIPITATION

In some areas this month's precipitation is more easily related to the mean sea level circulation than to the 700-mb. mean. Where the area was dominated by abnormally warm temperatures, precipitation in excess of normal

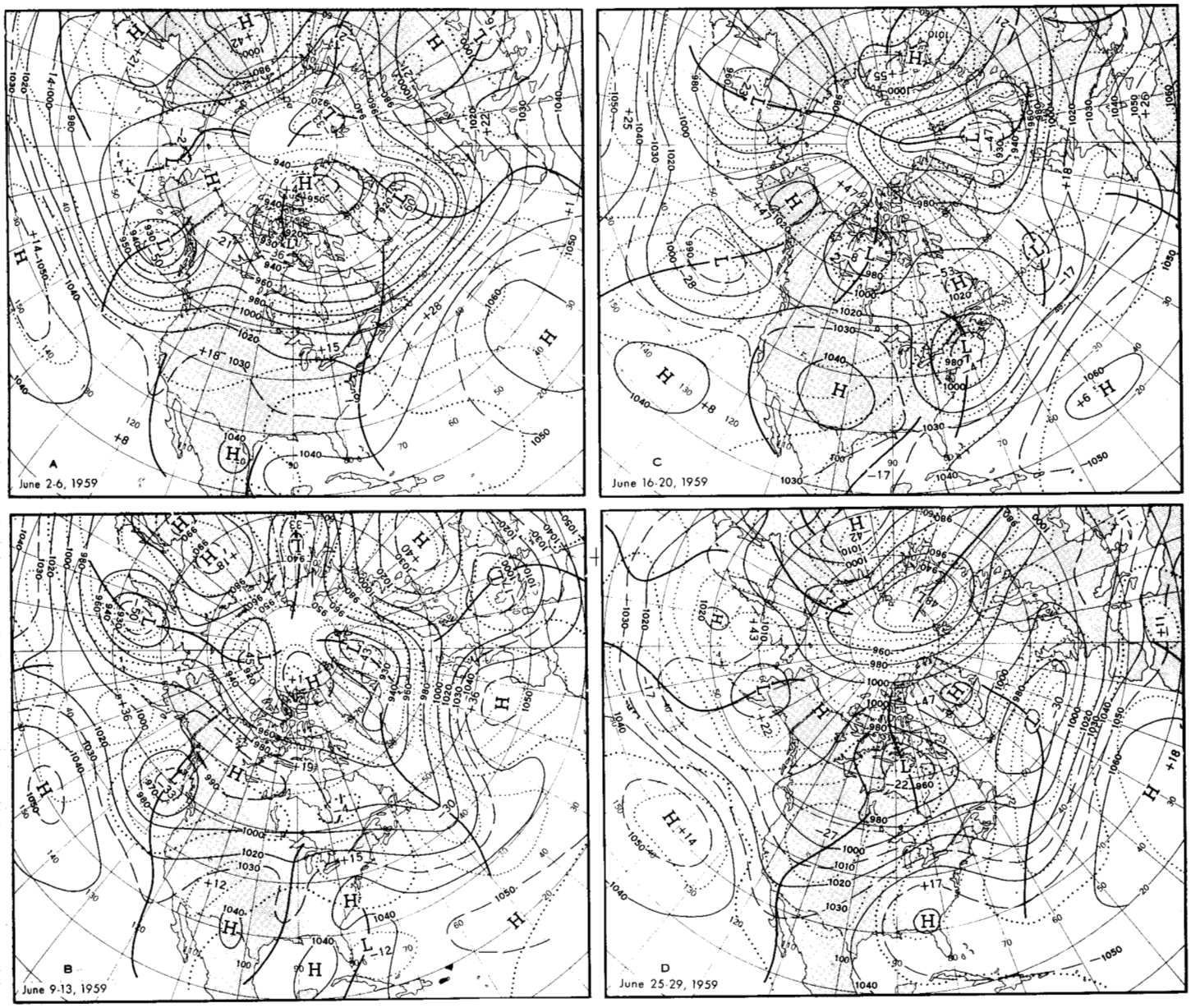

FIGURE 6.—Five-day mean 700-mb. contours (solid) and height departures from normal (dotted) both in tens of feet, for (A) June 2–6, (B) June 9–13, (C) June 16–20, (D) June 25–29, 1959. The zonal index was at its peak early in the month (A), and amplitudes of the mean waves were small. Blocking was most pronounced and the index lowest during the third week (C).

(fig. 10) coincided rather well with cyclonically curved mean sea level flow (fig. 11) from the southeast. The broad belt of southeasterly flow from the Gulf of Mexico provided adequate moisture, especially for orographic rainfall in the mountainous regions of New Mexico, Arizona, and Utah.

Locally severe thunderstorms were reported in the moist air mass over Kansas and Nebraska. A storm near Seldon, Kans., produced hail over a 10-square-mile area, measuring up to 3 feet deep in drifts, and total precipitation was estimated at more than 5 inches. Another severe storm moved over Grand Island, Nebr., where hail described as grapefruit sized was driven by winds up to 83 m.p.h.

A number of frontal waves skirted the western boundary of much-above-normal temperatures from northern Nevada to eastern Montana. Some of these storms were fairly vigorous but not violent, though squall lines in their warm sectors produced locally severe thunderstorms and a few tornadoes. One of the tornadoes occurred near Fargo, N. Dak., on the 9th and another near Green Bay, Wis., on the 10th.

A streak of above normal precipitation from Texas northeastward can be related to a weak mean trough at 700 mb. (fig. 1). Some of the rain in southern Texas was associated with tropical storm Beulah, which threatened the southern Texas coast on the 16th and 17th but moved inland well south of Brownsville.

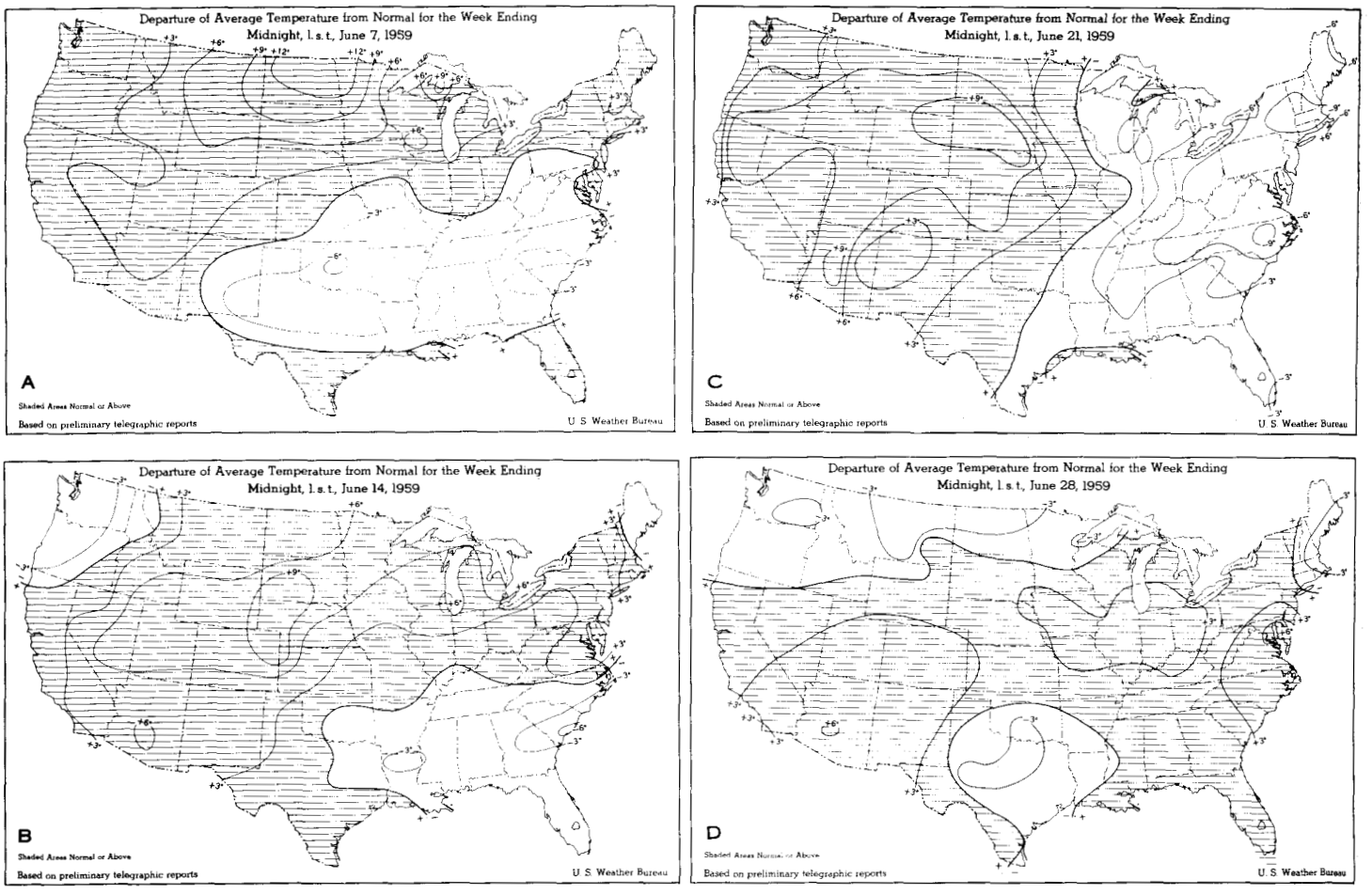

FIGURE 7.—Departures of average temperature (° F.) from normal for the weeks ending (A) June 7, (B) June 14, (C) June 21, and (D) June 28, 1959, concurrent with periods of figure 6. Temperatures were continuously warm from the Southwest to the Northern Plains and mostly cooler than normal over the South-Central and Southeastern States. Low temperatures set daily records at several stations from the Great Lakes southeastward during the third week. (From [6].)

Remnants of tropical storm Arlene contributed to excessive rainfall east-northeastward from the Louisiana coast. The heaviest rain and some of the most destructive severe weather came, however, with a weak-appearing tropical depression which crossed Florida on the 18th. This Low triggered at least two tornadoes, of which the most severe struck Miami, Fla., on the 17th, injuring about 100 persons, and causing damage estimated at $1½ million. A second tornado was reported in Palm Beach County but caused no injuries and little damage. Also on the 17th, squalls were reported near Fort Myers, Fla., and 24-hour rainfall at that station totaled 6.64 inches. Totals at Miami Beach and Miami Airport on the 18th were 6.28 and 5.95 inches, respectively. Rainfall was copious as far north as Orlando, where the 2-day total for the 17th and 18th was 4.40 inches.

North of Cape Hatteras much of the excessive rainfall can be attributed to the blocked New England Low, which was deepest during the third week and is reflected in the mean pattern of figure 1 as a negative anomaly center. In New England, Hartford, Conn., reported 22 cloudy days for a new June record and Portland, Maine, 24 cloudy days to equal the alltime record for any month.

Monthly mean westerly flow at 700 mb. was slightly above normal over the Pacific Northwest, helping to produce excessive rainfall in Oregon.

Precipitation was almost nonexistent in most of California and much of Arizona and Nevada, with positive 700-mb. anomalies and weaker than normal mean westerlies across the area. Sacramento, Calif., reported the driest spring in 110 years of record and Oakland the driest June. Drought continued at Tucson, with no measurable rain observed.

Parts of the Midwest were also dry. Springfield. Ill. reported the driest June in 80 years of record, and Detroit, Mich., had its driest June since 1895. Milwaukee, Wis., St. Louis. Mo., and Columbus, Ohio, reported their driest June since the early 1930's. Here the mean circulation was anticyclonic at sea level (fig. 11) and at the 700-mb. level (fig. 1).

6. HAWAII AND ALASKA

From Hawaii and Alaska came reports of warmth and dryness for June. Lihue, Kauai, Hawaii, had this to report [8]: "All of the following temperature values were higher than any previously recorded in the month of

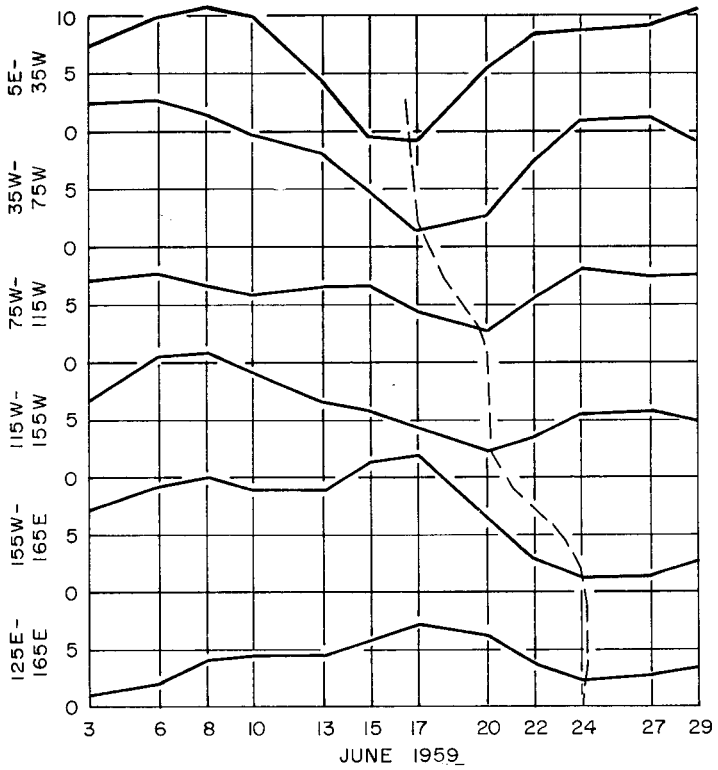

FIGURE 8.—Time variation of the 5-day mean zonal westerlies in regional zones of 40° longitude, in meters per second, for June 1959. Indices were computed for 35° to 55° N. and plotted on the last day of the period. Note the westward progression of minima in the curves during the second half-month.

June: Average Maximum, Average Minimum, Average Monthly, and the Highest for the month. Not only was the previous highest temperature exceeded on 1 day, but the previous record was equaled on 4 other days. Not once during the month did the temperature fall below normal. Dry weather continues over all parts of the island, the dryness being only slightly relieved by the showers on the last two days of the month." Honolulu Airport had only a trace of rain in June, the lowest on record there, and Hilo, Hawaii, reported a deficit from normal of 3.63 inches. The anomalies were associated with somewhat weaker than normal trade wind flow at sea level.

Anchorage, Alaska, reported [9] "Measurable precipitation fell on only 3 days, and totaled only 0.26 inch, less than one-third the normal amount. Thunderstorms are relatively rare in Anchorage, but one occurred on June 25. The mean temperature for the month was 56.6°, 2.9° higher than normal." At Fairbanks the temperature average 2.2° F. above normal; at Juneau, 1.6° F. above normal. Both stations reported thunderstorms and less than normal precipitation for the month.

Warmer than normal temperatures at these Alaskan stations were related in the usual sense to positive 700-mb. height anomalies (fig. 1). Below normal precipitation might be expected with the 700-mb. anomalous flow from the northeast rather than from the usual moisture source in the Gulf of Alaska.

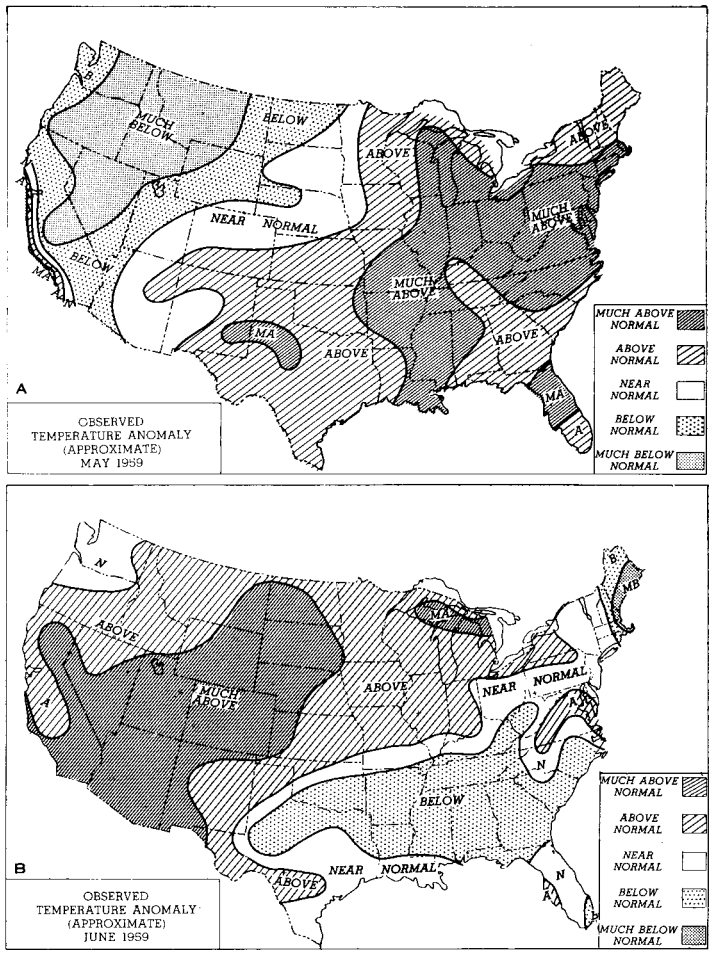

FIGURE 9.—Observed temperature anomaly for (A) May 1959 and (B) June 1959. Normal is established from 30-year averages for the period 1921 through 1950 with normal, below, and above occurring one-fourth of the time. Much below and much above each occur one-eighth of the time. Temperature anomalies in June changed more than one class from May at 60 percent of selected stations.

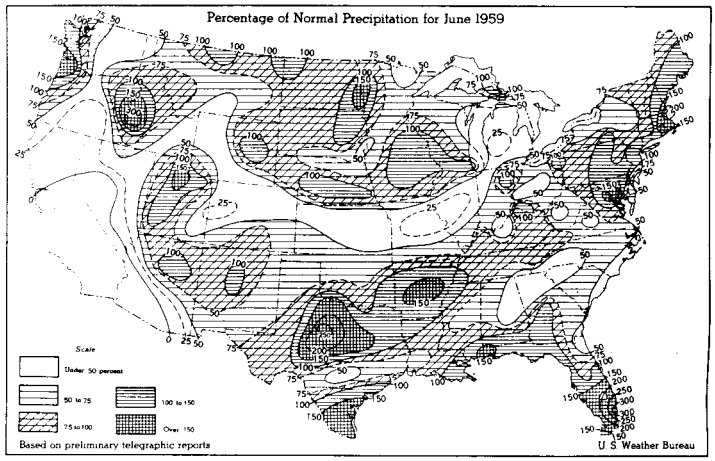

FIGURE 10.—Percentage of normal precipitation for June 1959 (from [7].) Much of the excessive precipitation in the South was related to tropical cyclones.

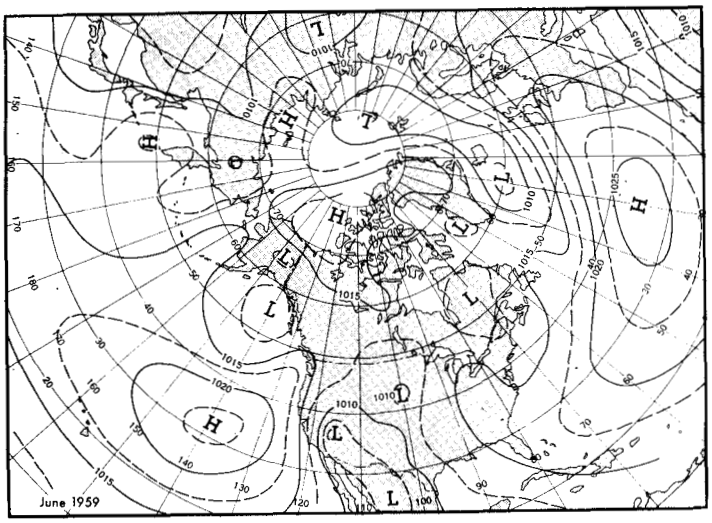

FIGURE 11.—Mean sea level pressure in millibars for June 1959. The broad belt of southeasterly flow from the Gulf of Mexico furnished moisture for numerous showers and thundershowers.

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Weather Note

TINTED RAIN AT DUNSTABLE, MASS., JUNE 6, 1959

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Greenish-yellow tinted rain was observed in Dunstable, Mass., at 4 p.m. EST, June 6, 1959. At the height of a thundershower, visibility was reduced at times to 20 feet by heavy rain which appeared to have a greenish tint, according to Edward Hill, Cooperative Weather Observer at Dunstable.

During the morning and afternoon the air over Dunstable contained a large amount of a greenish-yellow pollen. Prior to the rain, pollen was deposited on the ground, roofs, and other surfaces. The deposit on the inside of the thermometer shelter was nearly one-sixteenth inch thick. The contents of the rain gage were light green in color, due to a considerable amount of pollen.

U.S. GOVERNMENT PRINTING OFFICE: 1959